

Leipzig, Marburg, Karlsruhe, and Tübingen; during the short period that he spent at Tübingen he founded the Physical Institute. From 1880 to 1883 Braun was at Strasbourg, and he returned there permanently in 1895 to become professor of physics and director of the Physical Institute. He was called to the United States to testify in litigation involving radio broadcasting and then was detained when the United States entered World War I. He died in a Brooklyn hospital on 20 June 1918.

Although his contributions were all in the realm of pure science, in 1909 Braun shared the Nobel Prize in physics with Marconi for his practical contributions to wireless telegraphy. The work recognized by the Nobel committee was his fundamental modification of Marconi's transmitting system. Braun was first drawn to the study of wireless transmission by the puzzle of why it was so difficult to increase the range of the transmitter over 15 kilometers. It seemed to Braun that the range should easily be increased by increasing the power of the transmitter. His study of Hertz oscillators indicated that the attempt to increase the power output by increasing the length of the spark gap eventually reached a limit at which the spark caused a decrease in output. The solution, Braun thought, was to produce a sparkless antenna circuit. The power from the transmitter was coupled magnetically to the antenna circuit by a transformer effect instead of having the antenna directly in the power circuit. The principle has been applied to all such transmissions, including radio, radar, and television. A patent was granted on this circuit in 1899. Braun also developed an antenna that directed the transmission of electric waves in one direction.

In 1874 Braun published the results of his research on mineral metal sulfides. He found that these crystals conducted electric currents in only one direction. This information was important in electrical research and in measuring another property of substances, the electrical conductivity, but Braun's discovery did not have immediate practical application. In the early twentieth century the principle that Braun had discovered was employed in crystal radio receivers.

The first oscilloscope, or Braun tube, was introduced in 1897. In order to study high-frequency alternating currents Braun used the alternating voltage to move the electron beam within the cathode tube. The trace on the face of the cathode tube represented the amplitude and frequency of the alternating-current voltage. He then produced a graph of this trace by use of a rotating mirror. The Braun tube was a valuable laboratory instrument, and modifications of it are a basic device in electronic testing and research. The principle of the Braun tube, moving an electron

BRAUN, FERDINAND (*b.* Fulda, Germany, 6 June 1850; *d.* Brooklyn, New York, 20 June 1918), *physics*.

Braun studied at the University of Marburg and received his doctorate from the University of Berlin in 1872 with a dissertation on the vibrations of elastic rods and strings. He later did work in thermodynamics, but his major accomplishments were in electricity. Braun began his career as assistant to Quincke at Würzburg and later held positions at

beam by means of alternating voltage, is the principle on which all television tubes operate.

BIBLIOGRAPHY

I. ORIGINAL WORKS. Among Braun's writings are "On the Conduction of Current Through Sulpho-Metals," in *Poggendorff's Annalen*, **102** (1874), 550, and *Drahtlose Telegraphie durch Wasser und Luft* (Leipzig, 1901). His papers are listed in the Royal Society's *Catalogue of Scientific Papers, 1884-1900* (1914), pp. 773-774, and in the *International Catalogue of Scientific Literature* (1902), p. 65; (1904) p. 74; (1907) pp. 83-84; (1908) p. 85; (1912) pp. 74-75; (1917) pp. 73-74.

II. SECONDARY LITERATURE. There are no full-length biographies of Braun. He is best remembered by biographers for his Nobel Prize, although his most important work was in pure science. Some information is given in N. de V. Heathcote, *Nobel Prize Winners in Physics 1901-1950* (New York, 1953), pp. 81-86; and *The Nobel Prize-Winners and the Nobel Foundation 1901-1937* (Zurich, 1938), pp. 52-53.

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